

PL.2.1990-569

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**HEAD INJURY, MEMORY IMPAIRMENT  
AND OCCUPATIONAL SAFETY**  
**(Non-technical Summary)**



A PROJECT FUNDED BY THE  
OCCUPATIONAL HEALTH AND SAFETY  
HERITAGE GRANT PROGRAM



## **HEAD INJURY, MEMORY IMPAIRMENT**

Phone: 427-3530 in Edinboro or 800-345-3530 for the Occupational Health  
AND OCCUPATIONAL SAFETY

## **AND OCCUPATIONAL SAFETY**

and Safety Research Grant Program, National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, Atlanta, Georgia, USA.

#### (Non-technical Summary)



**NOTE FROM THE**

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not symptoms of the postconcussion syndrome. These include: memory changes, personality changes, sleep disturbances, anxiety, depression, etc. Because these symptoms often occur soon after head injury due to the job, safety in the workplace is threatened.

The long term goals of this project are to reduce injuries in the workplace, and improve the welfare of the worker and family by identifying the link between mental abilities and job demands. As an initial step to achieving this goal, the focus of our research was on the development of neurocognitive tests that would be sensitive to early and specific changes in mental abilities after minor head injury and vigilance. We were not attempting to establish specificity and sensitivity in identifying members of a ill-defined population as a diagnostic entity. Participants were interviewed to obtain personal and medical history in one session, followed on subsequent days by two sessions testing a wide range of memory and cognitive abilities: immediate memory, working memory,

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## Abstract

The match between a worker's abilities and job requirements is among the most important determinants of safety in the workplace. Although considerable effort has been made to designing equipment and safety devices aimed at physical abilities, relatively little is known about matching mental abilities, as they may change, with job demands. A worker may suffer damage to the central nervous system because of exposure to neurotoxins or injury. In addition to the obvious impairments caused by severe head injury, approximately 30% of accident victims who have had minor head injury or whiplash report symptoms of the post-traumatic syndrome (headache, sex drive changes, personality change, sleep disturbance, memory deficits). Because these workers often return soon after their accident to the job, safety in the workplace is threatened.

The long term goals of this project are to enhance safety in the workplace, and improve the welfare of the worker and family, by identifying the match between mental abilities and job demands. As an initial step in achieving this goal, the focus of our research was on the development of neurocognitive tests that would be sensitive to early and specific changes in mental abilities after minor head injury and whiplash. We were not attempting to establish specificity and sensitivity in identifying members of a clinical population as a diagnostic entity. Participants were interviewed to obtain personal and medical history in one session, followed on subsequent days by two sessions testing a wide range of memory and cognitive abilities: immediate memory, working memory,

prospective memory, memory for stories, language, spatial and motor abilities. Participants were men and women who were (1) in an accident resulting in minor head or whiplash injury and reporting typical post-traumatic symptoms matched with control subjects with no previous injury or symptoms; (2) not in an accident but reporting memory and cognitive impairments matched with control subjects. These control groups were age, gender and education matched subjects for groups 1 and 2 above. Patients were referred by physicians and had no neurological, medical or neuropsychological evidence to account for their reported memory impairment.

Our results showed that as a group, patients with post-traumatic symptoms and patients with suspected early dementia were impaired on the wide range of cognitive tests. The two patient groups showed distinctive patterns of deficits. Those with head injury/whiplash were deficient compared to their controls on time-oriented tasks and language, whereas the others were deficient on memory and cognitive tasks.

The results for trauma victims in this study were not due to depression, drugs or being in litigation. Change over a one-year period was almost non-existent. Depending on the conditions and demands of the workplace, the impairments could place the person and/or their co-workers at considerable risk for injury. The cumulative effect of even minor deficits extending across a diverse set of abilities could lead to substantial mismatches between worker competence and job demands.

In addition to replicating and extending the study of trauma

victims, research should examine mismatches caused by exposure to neurotoxins and by the normal aging process. Improving safety in the workplace has widespread ramifications for the worker and the family, as well as industry, business and the government.

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## Nontechnical Summary

### Head Injury, Memory Impairment and Occupational Safety

#### Final Report: Alberta Occupational Health and Safety

Allen R. Dobbs and Brendan Gail Rule

#### Background

##### 1. Safety: Matching Worker's Abilities and Job Demands.

Safety in the workplace has widespread ramifications for the individual worker, his or her family and society. The consequences of accidents involve the individual's health, job productivity, and family life, as well as financial costs to industry, business and government. Although failure to comply with safety regulations accounts for many accidents, the match between the worker's abilities and demands of the job are among the most important determinants of safety in the workplace. If machinery is too complex, requires too much strength or is awkward to operate, it is evident that workers are placed at risk with potentially disastrous consequences for themselves and co-workers. Because this type of worker-job mismatch and probability of accident is obvious, considerable research efforts have been directed toward the design of equipment and relevant safety devices to reduce hazards. These design efforts are not, however, tailored to characteristics of the individual workers and do not take into account mental changes in the individuals that may affect the safe operation of the equipment.

##### 2. Changes in Mental Abilities Due to Age, Exposure to Neurotoxins and Head Injury.

Importantly, but seldom explicitly recognized, the mental

abilities of the worker change with age. As with physical changes, mental changes do not begin only as the person approaches retirement age. Some changes that begin in the forties are directly responsible for worker-job mismatches and increase the potential for accidents. The importance of acknowledging changes in mental abilities that come with the normal aging process for safety in the workplace is discussed in a later section on implications of our research.

Sometimes there are abrupt changes in the worker that alter the worker's competence and create a mismatch between the person's abilities and the demands of the job. These changes may place the person and co-workers at risk for debilitating accidents. Physical injuries are clear examples, when that injury alters strength, coordination, agility or stamina. However, injuries resulting in changes in the mental abilities are arguably equal or perhaps even more direct causes of accidents. The obvious debilitation of severe head injuries precludes return to the workplace and the safety hazard that would have been caused by the change in the worker. Consequently, the concern for these workers is over fair compensation and possible rehabilitation.

The less well recognized implications for safety issues center around the potential worker-job mismatches caused by the less severe and thus less obvious changes in mental abilities that can be caused by "minor" head injuries, whiplash or chronic exposure to toxic fumes. The study of the cumulative effects of chemical neurotoxins is of increasing importance. The fumes from cleaning

solvents such as those used in automotive, truck, farm and heavy equipment repair shops, from paint and from dry cleaning agents are some of the types of chemical neurotoxins that alter the functioning of the brain. The effects of overexposure on physical and mental health are well documented. The new concern is over the increasing evidence that daily exposure to these fumes, even at levels meeting current occupational standards, may result in irreversible declines in memory and thinking abilities.

Head injury, sustained on or off the job site, is the most common source of memory disorder. In the case of minor head injury (loss of consciousness for less than one hour) and whiplash there are reportedly substantial and long term changes in mental functioning. These problems and associated headache, sleep and personality disturbances can affect performance on a wide variety of tasks.

Job requirements may include the ability to sustain attention, to remember to monitor gauges, to coordinate and perform multiple aspects of a task, to filter out visual and sound distractions, to accomplish fine motor movements in product assembly or operation of machinery, to maintain pace with changing information, or to follow directions. Mental deficits in memory and thinking abilities related to these specific aspects of the job often result in injury.

#### CURRENT RESEARCH PROJECT

##### 1. Long-Term Goals and Specific Objectives.

The long-term goals of the project are to enhance safety in

the workplace and improve the welfare of the worker, as well as his or her family by identifying the match between changing mental abilities of the worker and the task requirements of the job. To achieve this goal, several steps are needed in the research program: (1) develop tests that are sensitive to changes that occur with normal aging, early dementia, and damage resulting from head injury or exposure to neurotoxins, (2) analysis of mental requirements of tasks especially in high risk occupations, (3) develop and evaluate job re-training programs with reduced mental abilities due to age or accident, and (4) develop home support safety programs.

The specific objective of the project undertaken during this grant period was to develop sensitive tests measuring the deficits experienced by people who have had minor head injury (no loss of consciousness or loss of consciousness of less than one hour) or whiplash. In general, people having had whiplash or minor head injury usually return to the workplace soon after their injury, and may pose safety threats if they are cognitively impaired. About 30% of such victims report continuing problems with sleep disturbances, headaches, personality changes, sex drive changes, and memory problems. These symptoms characterize what has been called the post-traumatic syndrome (Balla, 1908; Barnat, 1986). Despite the severity of complaints by the victims and/or their families, it has often been difficult to document their basis with psychological and medical tests currently in use. Consequently, there continues to be controversy about the reality of the deficits

in persons having minor head injuries and that skepticism is even stronger regarding similar complaints of persons suffering whiplash injuries. As recently as 1986, a reviewer of the literature concluded that there is clear evidence for cognitive deficits in the first few days after mild injury but only weak evidence for the persistence of these deficits after a few weeks. In contrast, others have reported persistent deficits mainly in attention and concentration about two-and-a-half years after the injury. Unfortunately, in that study, the severity of injury included both mild and moderate cases.

The common lore among clinicians is that whiplash victims may be malingering and symptoms will disappear when litigation ceases. If the symptoms persist for any length of time, they are too often seen as due to depression. Such views have, of course, affected compensation decisions and require systematic study.

The work in this area has been incomplete in many important ways. First, the symptoms reported are often not related to actual cognitive performance. Second, the contribution of factors associated with the accident, such as length of time that consciousness is lost, the number of previous head injuries, depression and variety of other accident or person variables are not assessed. Considered together, it is evident that we do not know what factors may be more or less relevant to cognitive deficits. Third, and most important from our point of view, the tests used to assess cognitive performance are those that, although sensitive to serious and gross types of injury, may not be

sensitive enough to detect early or specific impairments that may nonetheless have serious consequences for productivity and safety. The purpose of this research was threefold: (1) to develop a battery of tests to detect specific memory and cognitive impairments of relevance to everyday mental functioning, (2) to identify predictors of cognitive impairment in minor head injury and whiplash by examining the contribution of demographic characteristics, symptoms of the post-traumatic syndrome, physical and emotional health, and accident related variables to cognitive performance, (3) to isolate patterns of cognitive performance that would distinguish trauma victims from those with a pathology suggestive of early dementia, especially at-risk for Alzheimer's disease.

## 2. Sample.

To provide norms for the tests and an adequate comparison group for this study, normal healthy people were recruited through advertisements to employees of the city (police, transportation, fire), service clubs, community leagues, associations. Approximately 650 volunteers participated in the study, conducted in our laboratory. From this larger pool of tested subjects, selection for comparison was based on several factors. For inclusion as control subjects, people must not have history of alcoholism, specific neurological diseases (e.g. epilepsy, Parkinson's) and could be matched to patient groups on the basis of education and gender. Our sample consisted of four groups: 59 trauma subjects and 59 age, gender and education matched controls;

25 at-risk subjects and their 25 age, gender and education matched control subjects. All 84 patients showed no evidence of neurological or neuropsychological deficits on standard tests. The trauma victims, referred by physicians, consisted of people who had lost consciousness for less than 30 minutes or who had whiplash. Evidence from animal studies shows that the neurological changes are similar for minor head injury and whiplash and in humans the symptoms are similar. The average time since accident was 2-1/2 years. The other memory group suffered memory problems leading to referral by a physician and, because of their age and the lack of an identifiable medical reason for their problems, are considered at risk for dementia, especially Alzheimer's disease. This group may have special relevance for the workplace of the future because demographic projections indicate that older workers will become a sizeable and necessary part of the workplace.

### 3. Procedure

Participants served in three separate sessions, each lasting one to one-and-a-half hours. In the first session, they were interviewed to obtain personal and medical history information in a structured format. In the next two sessions, they were given an extensive battery of tests, including tests for immediate memory (a series of digits to repeat), working memory (manipulation of information in immediate memory), prospective memory (remembering to do something in the future), prose comprehension (memory for short stories), paired associate learning (learning a list of word pairs), language tests (semantic memory, word finding), spatial

abilities, direction following abilities and motor abilities. The tests tap a wide variety of memory and cognitive abilities relevant to effective performance in daily living and in the workplace. The new tests developed by the applicants were working memory, prospective memory, one of the prose comprehension tasks, semantic memory and direction following.

#### **4. Results and Discussion.**

We found many interesting and important results that have implications for theoretical issues in our understanding of the psychological sequelae of minor head and whiplash injury. More importantly for practical concerns, the findings have direct implications for issues of productivity and safety in the workplace.

The performance on individual tasks showed that, compared to their respective control groups, the groups having experienced trauma and the (at-risk) group of older people with memory complaints were impaired on the wide range of tasks. Compared to their matched control groups, these tasks included: immediate memory, working memory, prospective memory, prose, language, spatial and motor abilities. On some tasks, the impairments were not large, on others the deficits were substantial. There is no doubt that trauma victims, as a group, suffer cognitive dysfunction that could compromise their work performance. Depending on the conditions and demands of the workplace, the impairments or nature of the impairments could place the person and/or their co-workers at considerable risk for injury.

The findings are noteworthy in two regards. First, neurological and other medical findings were negative for these people, meaning that they would be returned to their workplace based on medical information. Second, although the extent of impairments varied from being relatively mild on some tasks to more marked on others, it must be remembered that work situations are not limited to a single set of mental abilities as were assessed by individual tests. The workplace ordinarily requires a myriad of cognitive abilities. The cumulative effect of even minor deficits, when these extend across a diverse set of abilities, could lead to substantial mismatches between worker competence and job demands.

The deficits in memory and cognitive abilities of older (at-risk) group with memory complaints also extended across a wide range of cognitive abilities. Again, this is noteworthy because medical indices of these impairments were not apparent. Moreover, the constellation of deficits that accounted for most of the differences between the trauma group and their match control (normal) group were different from those associated with the older (at-risk) group. The cognitive patterns characterizing the at-risk for dementia were poor performance on nonverbal memory and cognitive tasks involving immediate memory and spatial abilities. The cognitive patterns characterizing trauma victims were those showing a slowing of responses on cognitive and motor tasks and language deficits. Slowed thinking and other mental abilities have, of course, obvious implications for job safety. In this regard, it must be recalled that the head trauma victims studied in

this research were people who showed no medical evidence of problems.

Third, this was the first study to examine a wide variety of sources of factors that could potentially influence performance after an accident. These included post-traumatic symptoms, accident related variables, demographic characteristics, physical and mental health. It is noteworthy that only age emerged as a significant predictor from among the other demographic variables and age at the time of the accident emerged as a significant predictor among the accident related variables. Clearly, for this sample, age is the single most important predictor of impaired mental performance, even though the mean age of this group is only 42 years. In contrast, the post-traumatic symptoms did not uniquely predict performance. Several particular variables did not account for the results obtained: extent of depression, the number of psychotropic drugs being used and whether or not the person was in litigation. Depression is believed by clinicians to be a source of memory deficits. Our lack of results in this regard add to the mounting evidence that questions such a relationship. Our results are also consistent with a growing number of studies failing to show that being in litigation is a factor affecting cognitive performance in the testing situation.

There were virtually no changes after a one-year interval, revealing no indications of either recovery or deterioration. Retesting after a longer period of time would be useful to investigate further effects of time on recovery or progressive

decline in function. However, it was, on the average, already 2-1/2 years since the accident on the first year these people were tested. Because we found no evidence of recovery a year later (3-1/2 years post injury), the deficits we found may well be permanent disabilities.

These disabilities do not affect only the injured person. Many of the people had lost successive jobs due to their inability to work at the same level of competence. Depending on their particular occupation, the change in competence may have placed the workers or their co-workers at risk for accidents. It also should be noted that the changes in these people affected the families. The sequential loss of jobs was undoubtedly very stressful. Moreover, it is likely that the depression and reported change in personality and sex drive were further sources of family disruption.

#### **IMPLICATIONS AND FURTHER RESEARCH DIRECTIONS**

##### **1. Minor Head Injury.**

This research was successful in accomplishing its goals. The battery of tests discriminates between people who have experienced minor head and whiplash injury and people who have memory impairment likely to develop progressively into dementia. This battery is easy to administer and is acceptable to participants without frustrating or fatiguing them. The battery may serve as a tool to identify persons whose actual impairment is likely to reduce job performance or safety. Further research is needed to examine differentiating patterns against other pathologies and

damage from job-related exposure to neurotoxins.

Our data show that trauma victims who show no neurological injury continue to show post-traumatic syndrome symptoms when tested an average of almost three years post injury and they show considerable cognitive impairment. These data, in conjunction with our data showing declines on particular memory and cognitive dimensions as a function of aging, suggest that investigations should now focus on analysis of the memory and cognitive abilities required by high-risk jobs. If a mismatch between job requirements and cognitive abilities occurs, it is evident that efficiency, productivity, and safety may suffer.

These matters are of paramount importance. The number of head injuries from traffic, sports and job-related accidents is high. The demographic shifts in aging indicate that older people will have to remain in the workplace. Adjustments to cognitive abilities and task mismatches may necessitate job re-training. To meet these forthcoming problems, considerably more research must address the issues.

## 2. Exposure to Neurotoxins.

There are aspects of some work environments that can accentuate memory problems. We are all well apprised of the consequences of accidental over-exposure to hazardous fumes (chemical neurotoxins).

In recognition of the severe, sometimes fatal, consequences of over-exposure, the Alberta Occupational Health and Safety Heritage Research Program financed the production of a video titled "The

Lucky Ones". The video depicts a knock down (loss of consciousness) of a worker and the disastrous consequences of responding to one's instinct to assist that worker. The chemicals causing the knock down are airborne and invisible, and affect all workers attempting the rescue if they are not properly fitted with masks and other safety equipment. If the worker survives the knock down, he or she is left with temporary or permanent and often severe changes in mental abilities. The dramatic changes in mental abilities due to the chemical over-exposure and the effects on the family are shown through interviews with accident victims. Although this is an important documentary and training video, it is directed only toward over-exposure. It does not address the cumulative effects of "normal exposure" to these and other chemical neurotoxins such as the fumes from cleaning solvents. Current research is building a case for cumulative effects of daily exposure to these fumes, and that these cumulative effects can permanently alter mental abilities. One disconcerting aspect of those findings is that these permanent changes in a person's memory and thinking abilities can occur with daily exposure to levels of these fumes that may be common place in Alberta's industrial settings. When these industry-caused changes in mental abilities are added to the naturally occurring alterations due to age, it is possible that our estimates of the changed abilities in older workers are under-estimates, and that older workers who have been chronically exposed to the fumes from solvents, paints, and refining processes may be even more at risk than had been presumed.

Research is needed to address these issues.

3. Normal Aging.

Our earlier research had as its goal the discovery of the kind and extent of changes in mental abilities that are a part of normal aging. That research included over 650 people who ranged in age from 30 to over 75 years of age. The research documented that many aspects of memory, thinking and motor abilities do change in normal aging but that some aspects of mental abilities are not affected. This information is of importance to those interested in occupational safety because, as workers age, their mental abilities may not fit their job requirements.

All too often the public and even those responsible for safety programs think of changes in mental abilities as being important only for those in white-collar jobs. This simply is not the case. Our research has identified a number of changes in mental abilities that occur normally as people grow older that have direct relevance for performance in blue-collar jobs. In fact, with a little reflection on the risks and causes of accidents on blue-collar worksites, anyone can identify a wide variety of accidents that can result from memory failures, poor judgement, lapses in attention, distractibility and other mental disruptions which can occur without head injury. Reductions in the ability to sustain attention, to remember to monitor gauges, to coordinate and perform multiple aspects of a task, to filter out visual and sound distractions, to accomplish fine motor movements required in product assembly or operation of machinery, to hear in high noise

environments, to maintain pace with changing information, are but some of the changes that accompany the normal aging process.

This information about changes that accompany normal aging is now more important than ever before, because of the dramatic changes that are occurring in our population. The proportion of our population that is over 65 years of age is increasing at an unprecedented rate. At the same time, the proportion of our population that is young is decreasing at an unprecedented rate. Mandatory retirement is a thing of the past, and inducements for early retirement will soon become yesterday's idea. This is because there will not be enough young workers to fill the jobs. Inducements to keep older workers on the job will become the reality. Older workers are not the same as they were at 20 to 40 years of age. They bring with them expertise and knowledge of great value. They also appear at the worksite with different mental abilities that must be accommodated in the workplace. A failure to recognize either the expertise and talents or the changes in basic mental abilities of older workers will mean a loss of productivity and increased accidents with very real human and economic costs.

Our previous research is an important beginning to documenting the changes in mental abilities that accompany normal aging. Our findings, in combination with those of other researchers, are sufficient to begin the important task of applying what is known about age-related changes in mental abilities to safety and efficiency in the workplace. This is not a simple task, but it is

one that can be accomplished. This application is of importance to the future when the older worker will become both common and necessary. But, its importance now cannot be dismissed. There are fewer injuries to older as compared to younger workers, but the injuries are more severe, more disabling, longer lasting and extract more financial compensation. Just how much of the accidents of older workers is due to changes in their mental abilities is unknown, as are the remedies. But, known changes in spatial and orientation abilities can easily cause falls by roofers, builders and others. Known changes in distractibility and decreased abilities to monitor gauges, site lines or utility wires, and difficulties in maintaining in memory the constant changes (such as the location of co-workers) can have severe consequences if the person is operating heavy equipment, working in the forestry or oil industry.

#### 4. Safety: Productivity, Welfare of the Worker, Welfare of the Family.

Throughout this report we have emphasized the importance of safety to the productivity and the welfare of the worker. It would be a mistake, however, to limit ourselves to such a nearsighted view of the consequences of injuries to workers. Injuries to workers have direct and often dramatic consequences to the worker's family. Potential loss of the worker's income is obvious. But, in the case of debilitating physical injury, there is often a new responsibility of providing in-home care by the family members, forced changes in life-style and leisure activities. The stress

and strain in interpersonal relations because of mental problems can lead to family disintegration. In some cases there is the loss of the family home, not because of financial restriction, but because the injury precludes climbing the stairs of a two-story or split-level home, or the injured person is no longer able to accomplish home maintenance, is no longer able to drive and thus requires a residence that is closer to public transportation. Safety, then, is not a matter of concern only to and for the worker. The problems caused by injury have a broad ranging effect on the person and the family.





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